

Optimize FPGA & SoC Configuration for Speed, Resilience & Adaptability

2Q 2024

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Avalanche Technology



avalanchetechnology

Agenda

Roadmap Update

Qualification and Ecosystem Update

Boot Solutions – Device Level

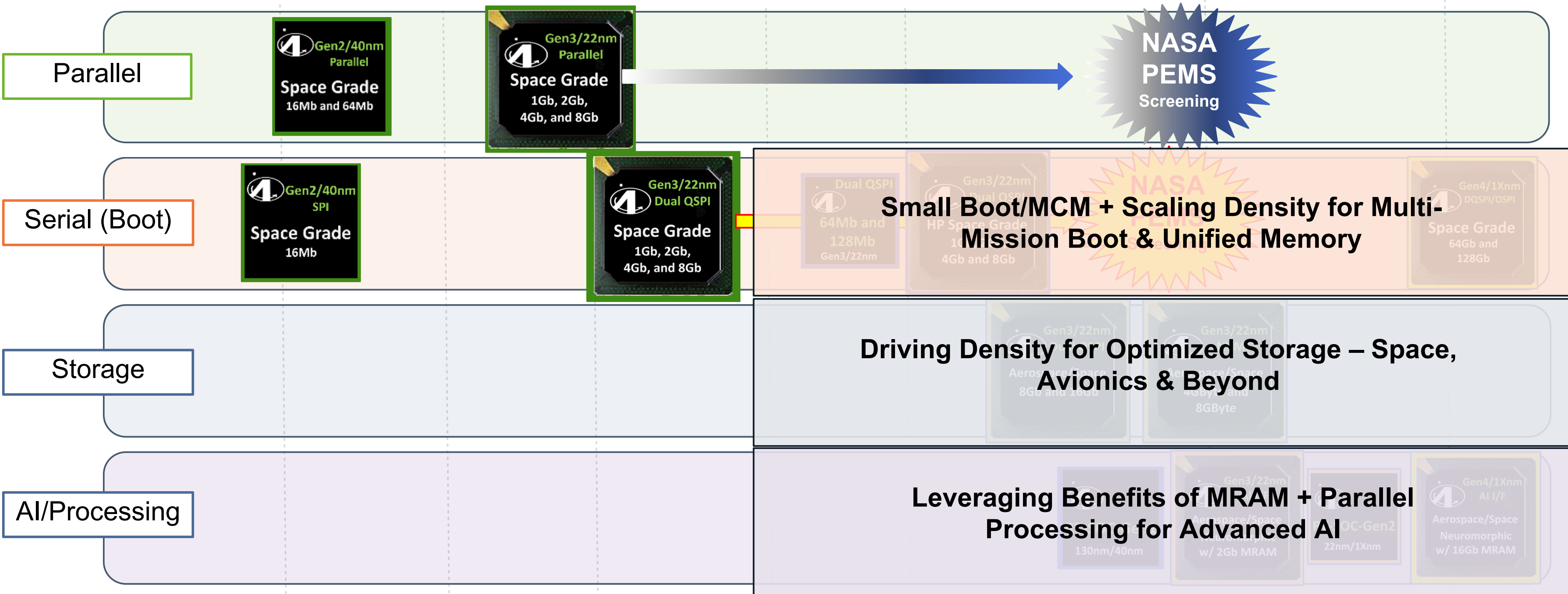
Enabled Platforms – Storage

Enabled Platforms – Board & Device

Recap

Roadmap Update

Avalanche MRAM/Processing Product Roadmap



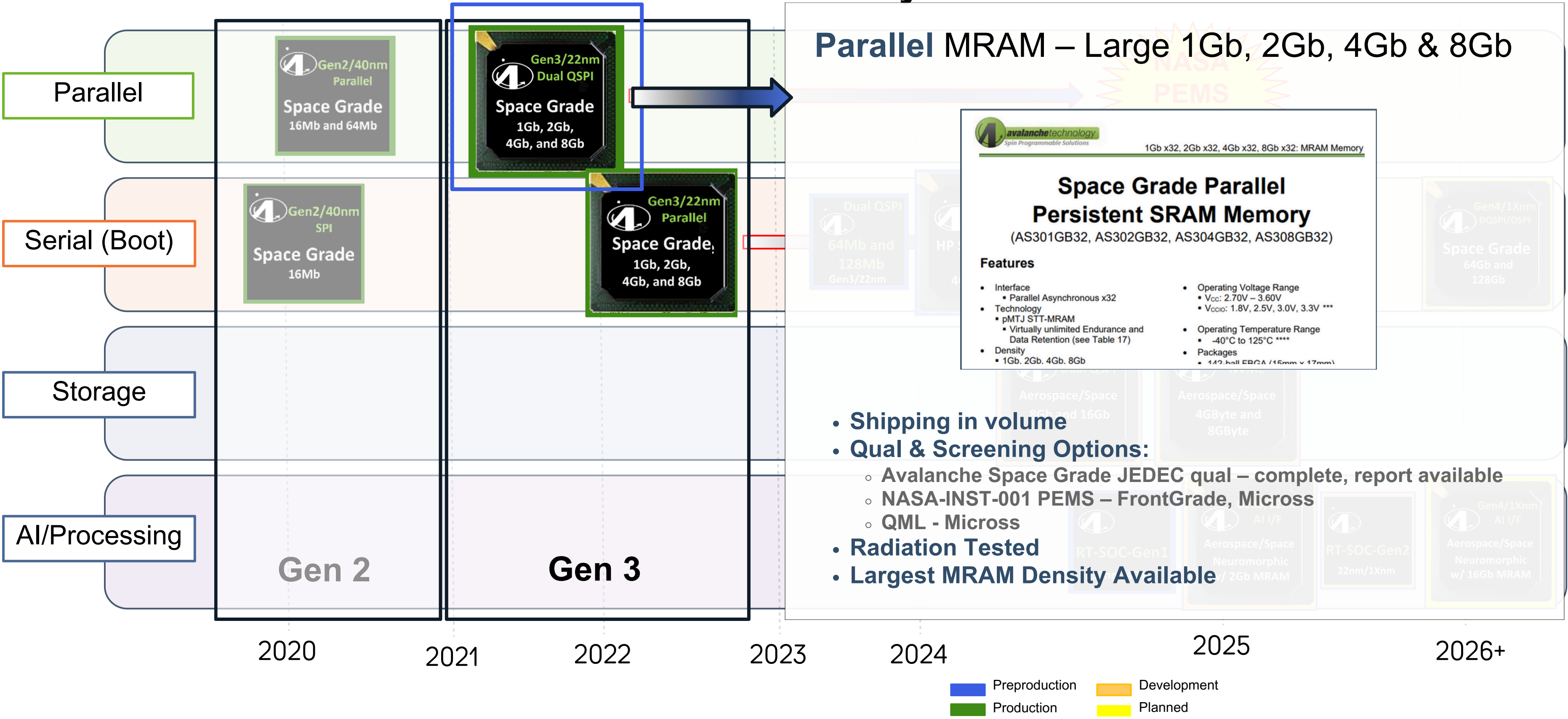
Small Boot/MCM + Scaling Density for Multi-Mission Boot & Unified Memory

Driving Density for Optimized Storage – Space, Avionics & Beyond

Leveraging Benefits of MRAM + Parallel Processing for Advanced AI

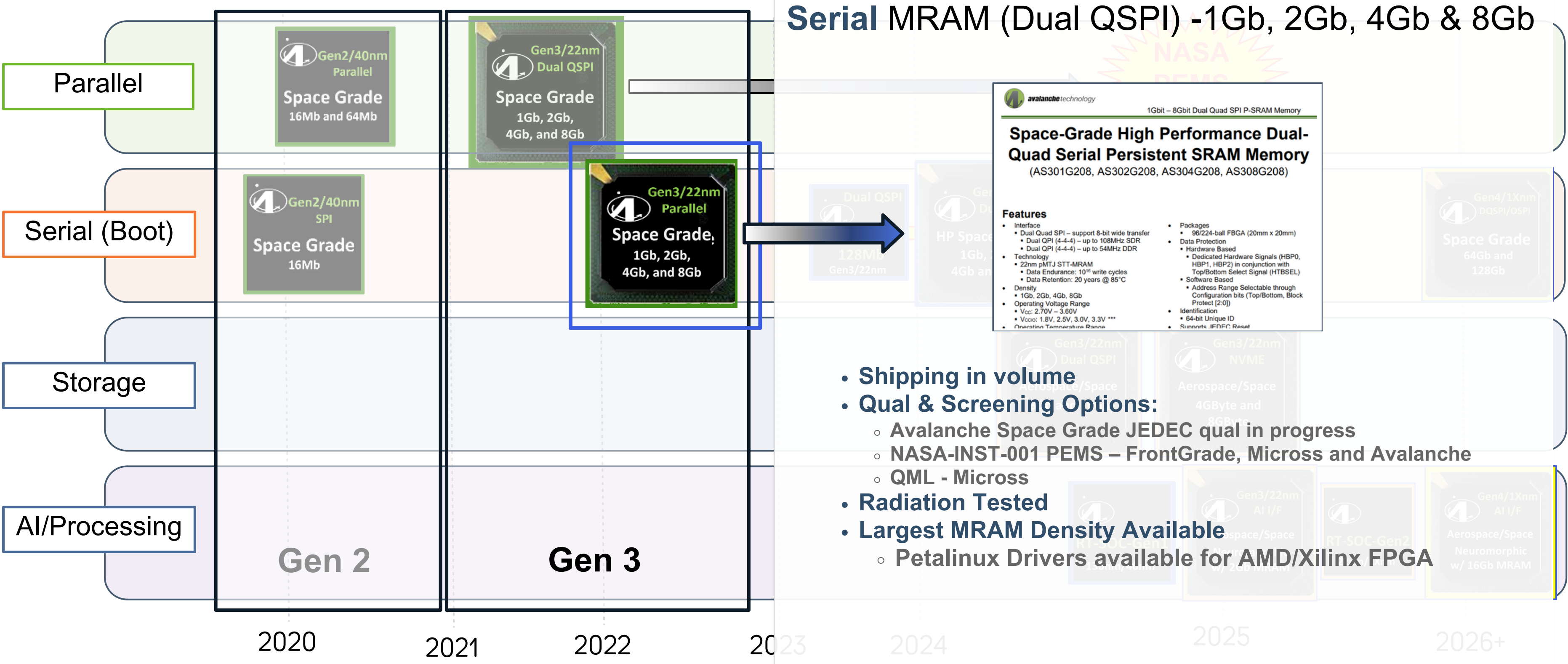
- Preproduction (Blue)
- Production (Green)
- Development (Orange)
- Planned (Yellow)

Avalanche MRAM Solutions Available Today



Avalanche MRAM Solutions Available Today – Ideal for Configuration

Serial MRAM (Dual QSPI) -1Gb, 2Gb, 4Gb & 8Gb



1Gbit – 8Gbit Dual Quad SPI P-SRAM Memory

Space-Grade High Performance Dual-Quad Serial Persistent SRAM Memory
(AS301G208, AS302G208, AS304G208, AS308G208)

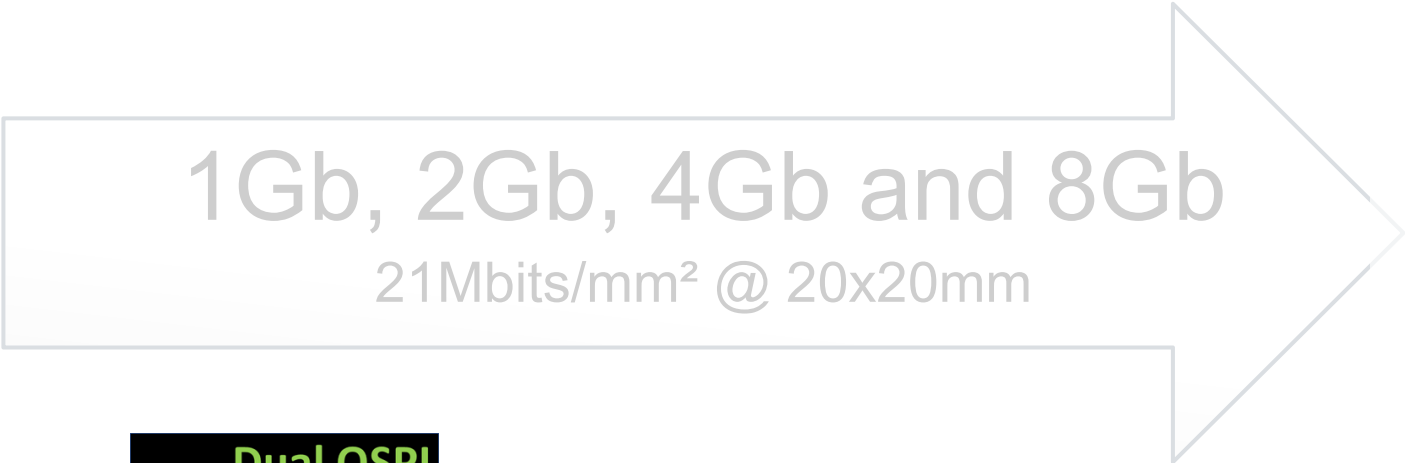
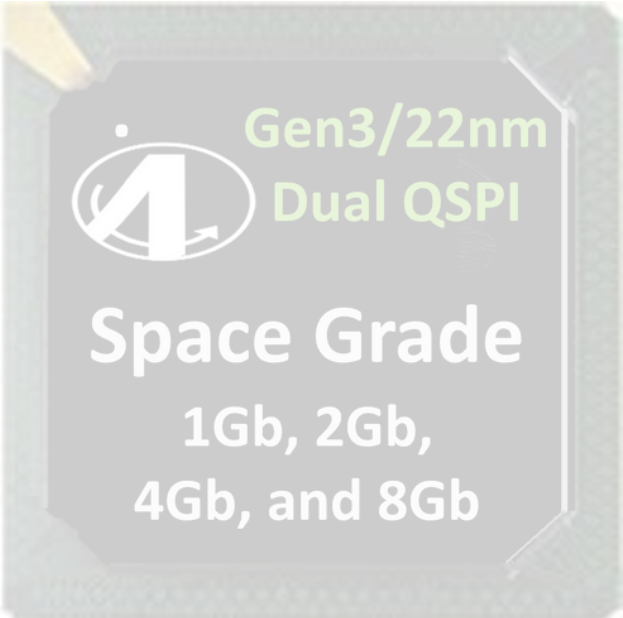
Features

- Interface
 - Dual Quad SPI – support 8-bit wide transfer
 - Dual QPI (4-4-4) – up to 108MHz SDR
 - Dual QPI (4-4-4) – up to 54MHz DDR
- Technology
 - 22nm pMTJ STT-MRAM
 - Data Endurance: 10¹⁶ write cycles
 - Data Retention: 20 years @ 85°C
- Density
 - 1Gb, 2Gb, 4Gb, 8Gb
- Operating Voltage Range
 - Vcc: 2.70V – 3.60V
 - Vccio: 1.8V, 2.5V, 3.0V, 3.3V ***
 - Operating Temperature Range
- Packages
 - 96/224-ball FBGA (20mm x 20mm)
- Data Protection
 - Hardware Based
 - Dedicated Hardware Signals (HBP0, HBP1, HBP2) in conjunction with Top/Bottom Select Signal (HTBSEL)
 - Software Based
 - Address Range Selectable through Configuration bits (Top/Bottom, Block Protect [2:0])
- Identification
 - 64-bit Unique ID
 - Supports JEDFC Reset

- Shipping in volume
- Qual & Screening Options:
 - Avalanche Space Grade JEDEC qual in progress
 - NASA-INST-001 PEMS – FrontGrade, Micross and Avalanche
 - QML - Micross
- Radiation Tested
- Largest MRAM Density Available
 - Petalinux Drivers available for AMD/Xilinx FPGA

■ Preproduction ■ Development
■ Production ■ Planned

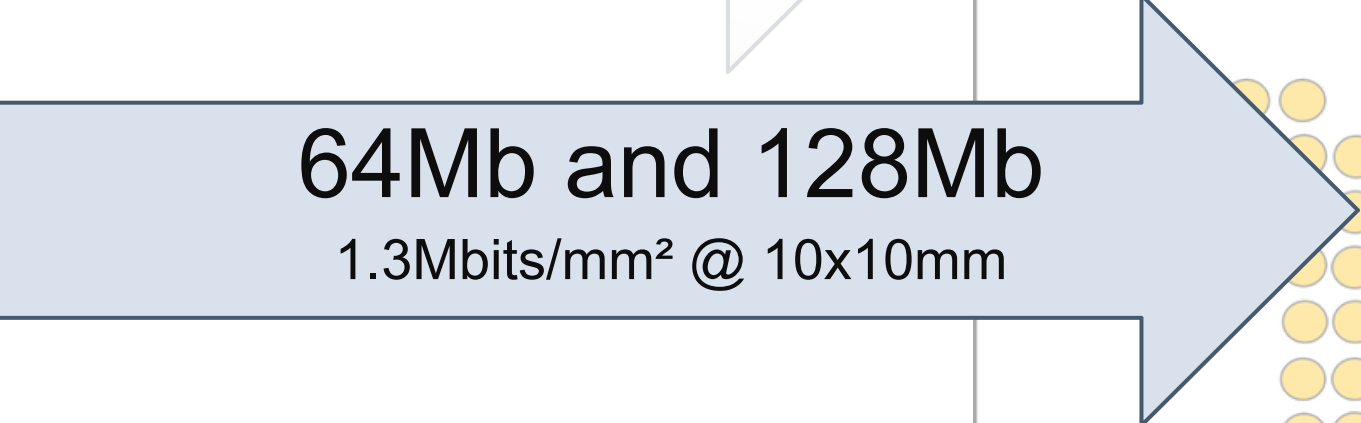
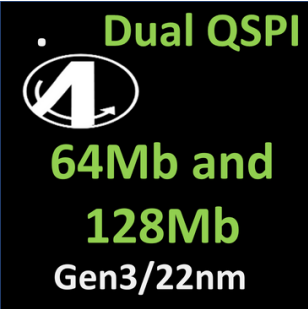
Low Density Serial (Dual QSPI) – 64Mb and 128Mb Gen3



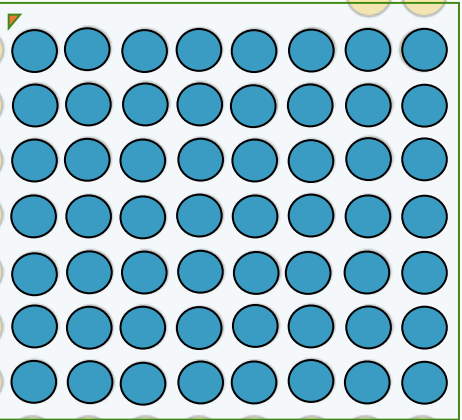
Standard FBGA96



20mm



10mm



10mm

20mm



- Leverages Gen3 Radiation Legacy**
- Ultra Low Power (~15mA per device)**
- Ideal for Advanced SoC/FPGA boot**
 - Compact images
 - Flexible, but robust write protection schemes
- Single or Dual QSPI Interface**

Space Grade vs Space Grade-E- *Preview*



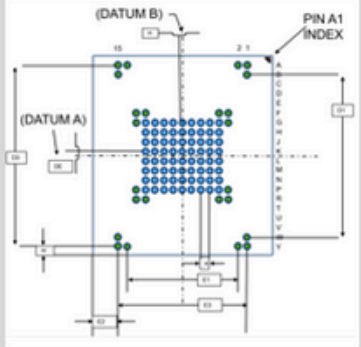
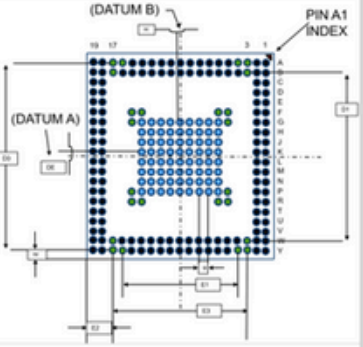
Status

Space Grade DQSPI:
In production since 6/23
JEDEC qual 2Q24

Space Grade-E DQSPI:
Prototyping 3Q24
JEDEC qual 2025

Advantages

- Faster Booting**
- Improved Radiation Performance**
- Improved Mechanical Robustness**

	Space Grade DQSPI	Space Grade-E DQSPI
MRAM die	Gen 3 1Gb die, stacked to x1, 2, 4, or 8	
Endurance	10 ¹⁶ write cycles	
Retention	20 years at 85degC	
Interface chiplet	RT-FPGA	22nm RHBD
Package (footprint & electrically compatible)	96 ball FBGA (20x20mm) 	224 ball FBGA (20x20mm) 
Performance	54MHz SDR/ 40MHz DDR	100MHz SDR / 50 MHz DDR
TID	75krad	300krad
LET	45MeV**	~75MeV**
Availability	Production	mid-2024 sampling

HP-DQSPI specs are preliminary, subject to additional testing & validation.
**See datasheet for guidance

Qualification and Ecosystem

Powered by Avalanche – MRAM Device Ecosystem



Industrial
Space Grade
PEMS through DPACI

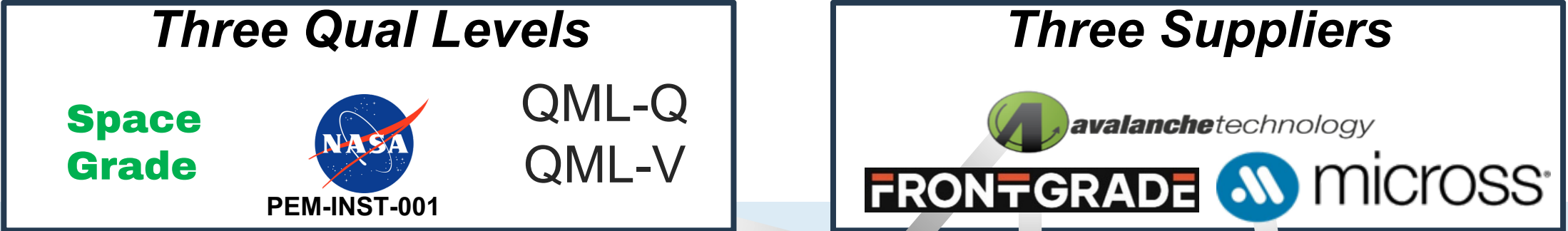


Space Grade
QED, PEMS, and RadHard
30-year Hi-Rel Qual Heritage
Plastic, Die, Hermetic, and MCM



Space Grade
QED, PEMS, and RadHard
Standard and Custom
30-year Qual Heritage

Powered by Avalanche - Qual & Screening Ecosystem Options



Packaging	Plastic Encapsulated				Hermetic, Ceramic, MCM
Qual Level	JEDEC + 48 hour burn-in	NASA PEMS			QML
Vendor	avalanche technology	avalanche technology	FRONTGRADE	microcross	microcross
Product Family	Space Grade	QED Series*	UT8MRQ Series	QED Series*	Multiple
Avalanche MRAM Generation	Gen3	Gen3	Gen3	Gen2 & Gen3	Gen2 & Gen3
Comments	Representative radiation reports only.	The exact same packaged device, custom marked to vendor; each responsible for their own Qual & Screening flow. Datasheet of origin is Avalanche.			Multiple package, screening & radiation options for each
Space Grade-E DQSPI & Parallel	TID	100kRad	100kRad	100kRad	300kRad
	SEE	75MeV	75MeV	75MeV	75MeV
Space Grade DQSPI	TID	75kRad	75kRad	75kRad	75kRad
	SEE	45MeV	45MeV	37MeV	45MeV
ITAR	No	No	Yes	Yes	Yes

* Subject to customer demand; initially Gen 3 High Density DQSPI

Boot Solutions - Device Level

Enabled Booting and nvStorage for AMD/Xilinx Devices

SW-Defined Platforms for Space – Respond to Threats in Real Time

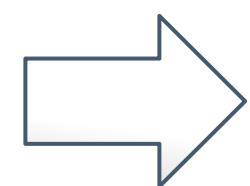
Support Resources Available



Now

Historically supported by

+ Radiation Mitigation & Control Circuitry



PROM¹
Golden FPGA Images
Boot Images
Read Only

NOR²
Alt Boot Images, RTOS, etc.
In-Orbit S/W updates
Write Protectable

P-SRAM³
Data Logging
Execute Memory
Read/Write

Family	Petalinux Support				Fabric Only No O/S
	23.2	23.1	22.2	22.1	
Versal	✓	✓	✓	✓	✓
Ultrascale+	✓	✓	✓	✓	✓
Ultrascale	✓	✓	✓	✓	✓

<https://www.avalanche-technology.com/support/development-kits/>

Gen 3 Space Grade Dual QSPI P-SRAM™ Kit for Xilinx

Development Kit:
[Download the User Guide](#)
[Download the Sample Code](#)
[Xilinx/AMD Versal Boot Linux Drivers](#)

Reference Design:
[Download the Schematic, Board Layout, Gerber, BOMs](#)

Orderable Part Numbers:
 Kit: AK30X208XILCCSOC
 Socket: ABGA96-1-20x20

No redundancy, mitigation or control needed
 Dramatically simplified hw & sw architecture, rapid boot
 In Orbit FOTA support: multi-mission adaptability ENABLED

Enabled auto-updating RT PolarFire's on-board Flash



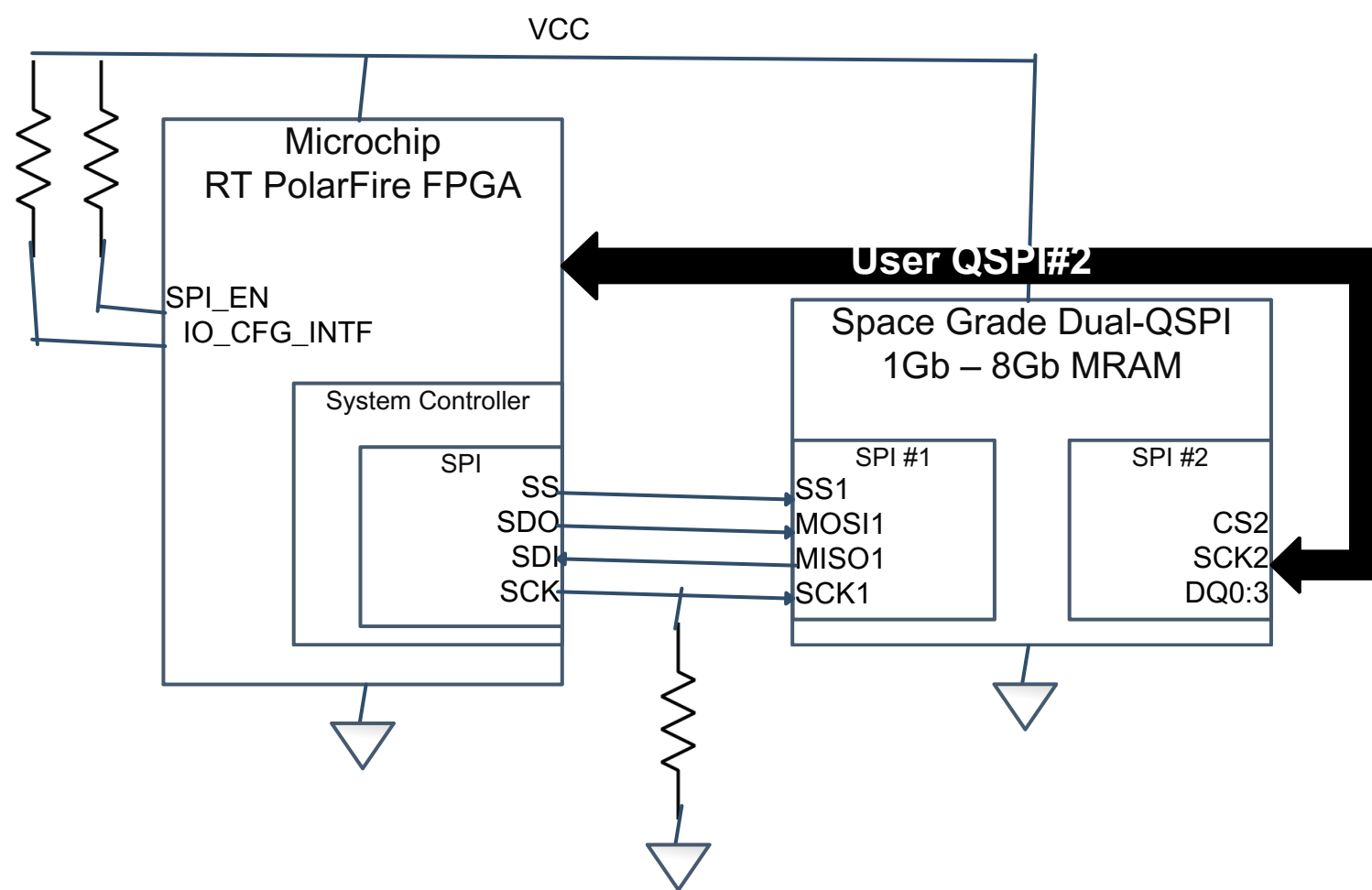
Auto-updating RT PolarFire FPGAs w/MRAM

RT PolarFire use SFDP [Serial Flash Discoverable Parameters]. Part of the JESD216 standard.

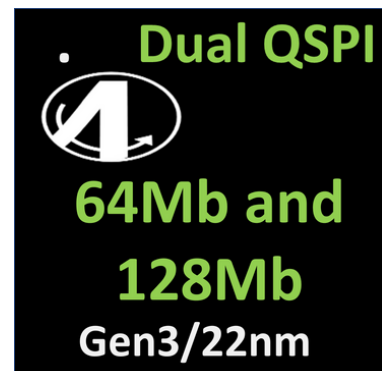
Avalanche DQSPI MRAMs do not support SFDP.

However, Avalanche DQSPI MRAMs have successfully auto-updated the RT PolarFire's on-board flash using its extended address register.

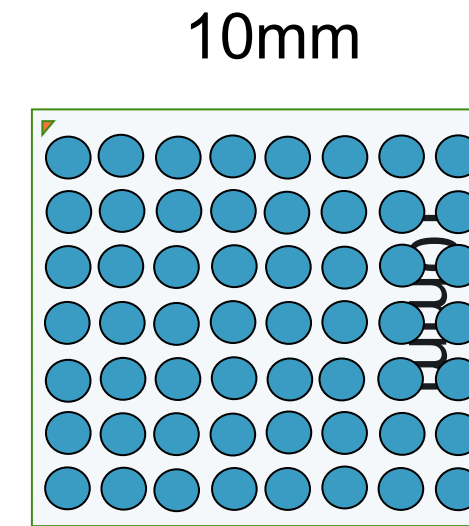
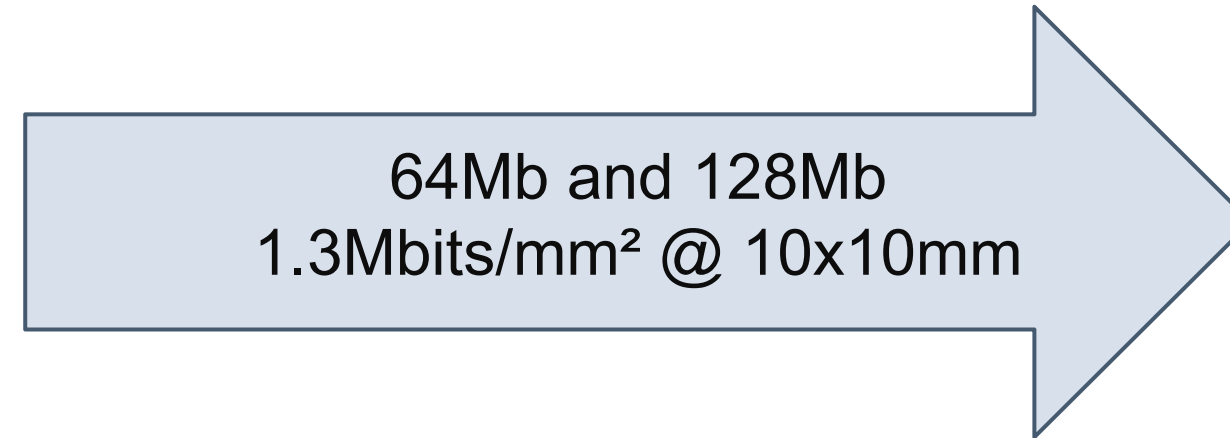
App note will be available on June 1, 2024



Mini-Boot: Low Density Serial (Dual QSPI) – 64Mb and 128Mb Gen3

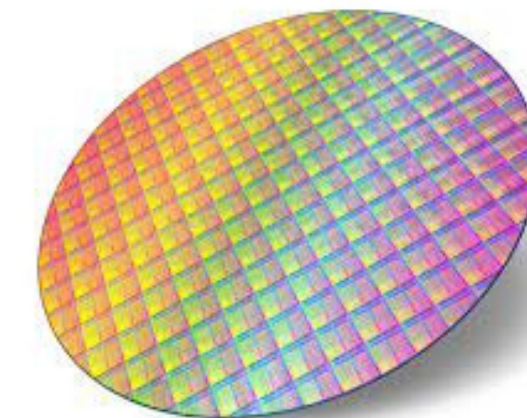
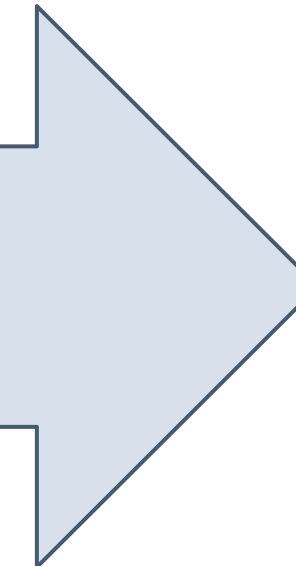


Gen 3 Devices
Sampling 2Q24



Gen 3 Die Form
Sampling 3Q24

	AV64M	
	X (um)	Y (um)
Die Size (W/O Scribe)	5118.03	3974.04
Scribe (80um)	80	80
Die Size (W/ 80u Scribe)	5198.03	4054.04

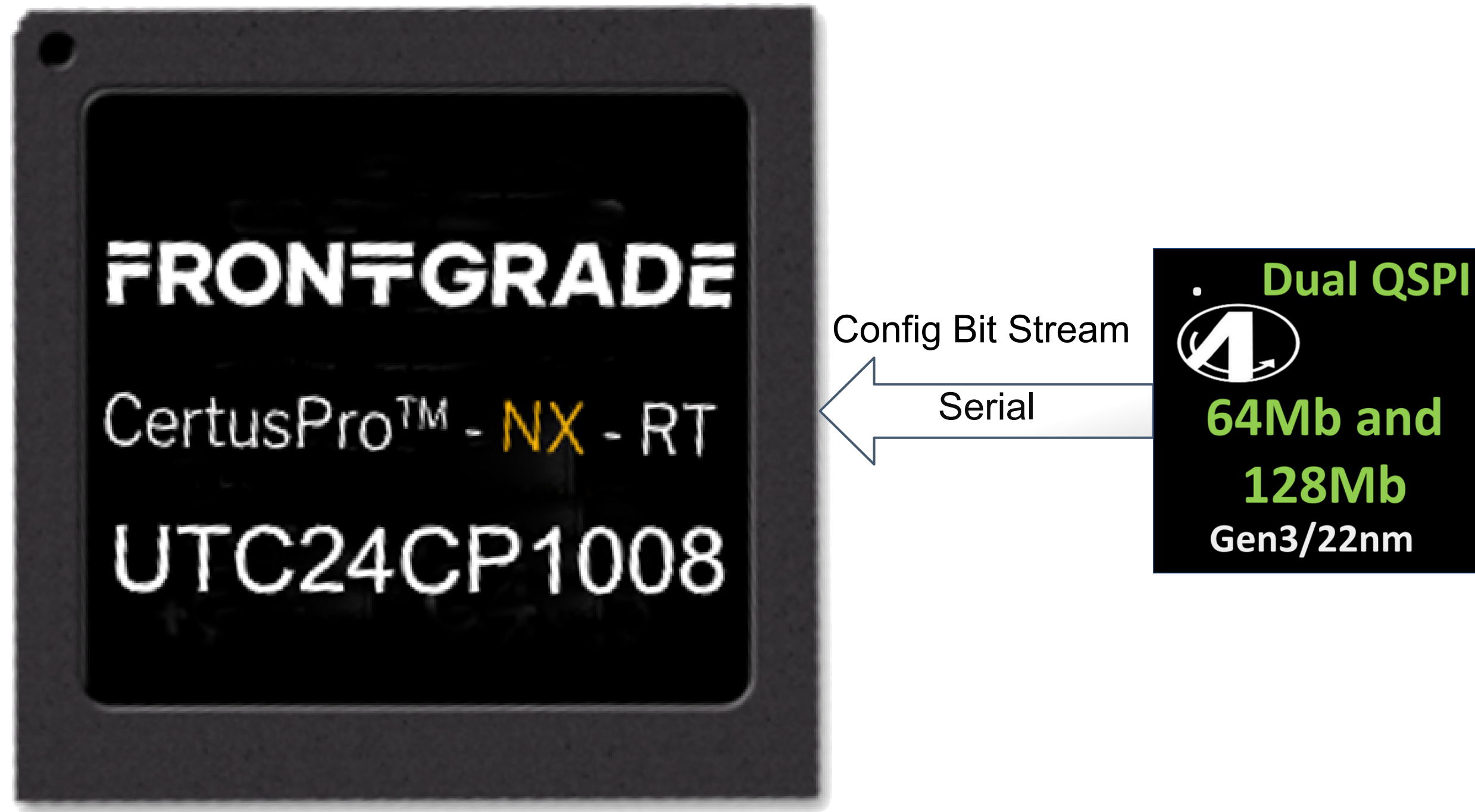


Die has Serial and Parallel Interfaces

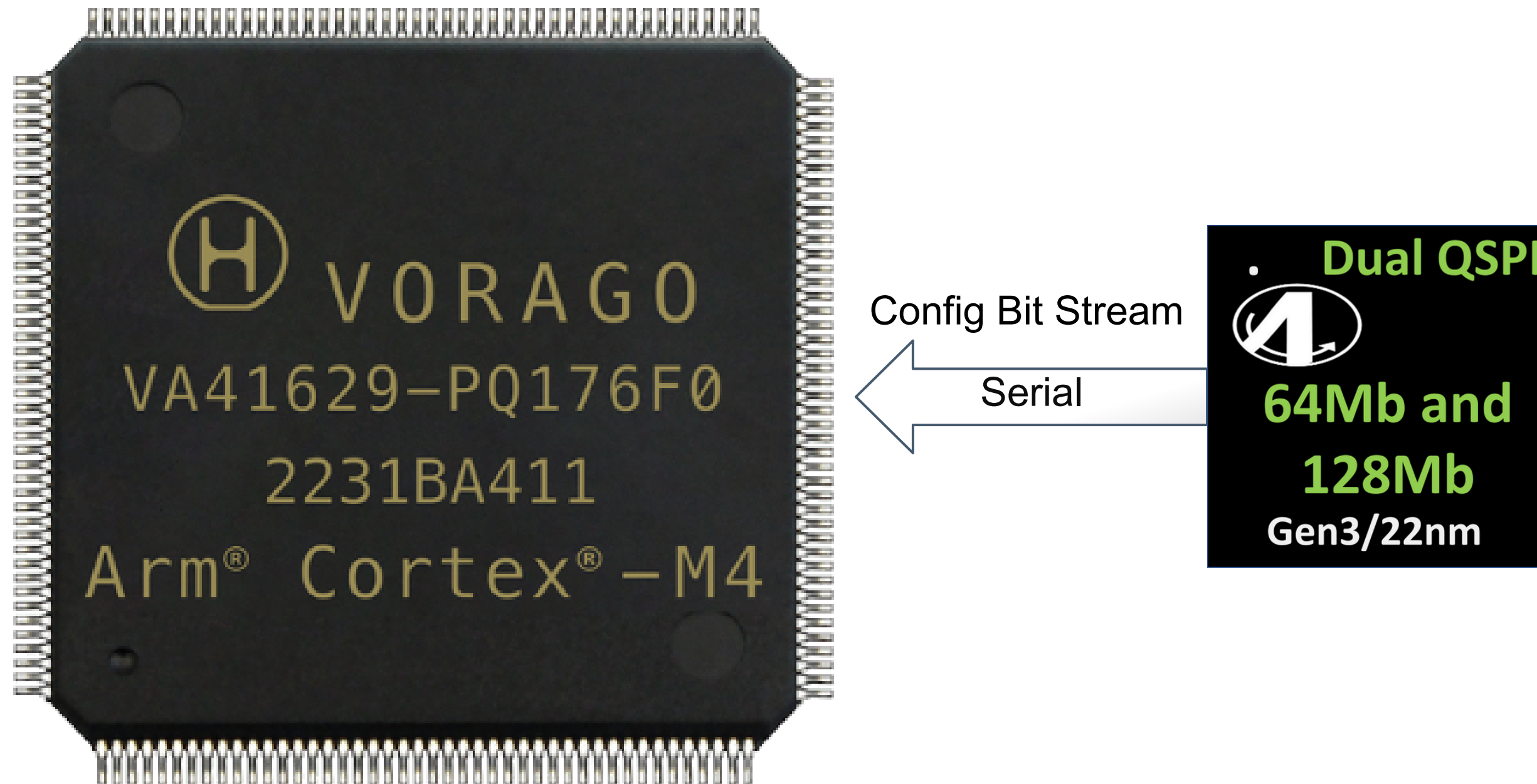
- Leverages Gen3 Radiation Legacy
- Ultra Low Power (~15mA per device)
- Ideal for Advanced SoC/FPGA boot
 - Compact images
 - Flexible, but robust write protection schemes
- Single or Dual QSPI Interface

Coming soon to a popular RH SoC near you

Enabling Booting for Frontgrade/Lattice CertusPro FPGAs



Enabling Booting for Vorago ARM-M4 Series Family SoCs




Enabling Booting & Working Memory for Gaisler GR716 LEON3FT Processor

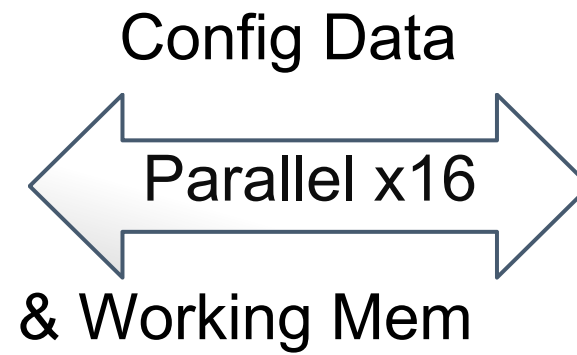



Config Bit Stream



Dual QSPI

64Mb and 128Mb
Gen3/22nm

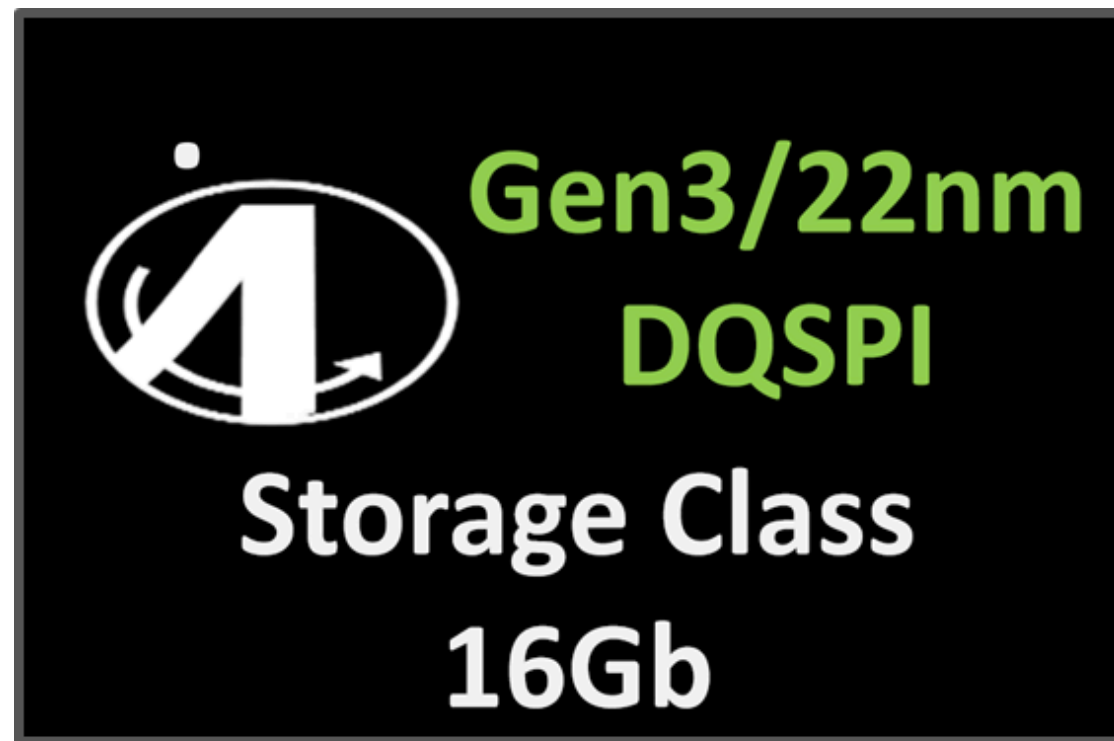
OR



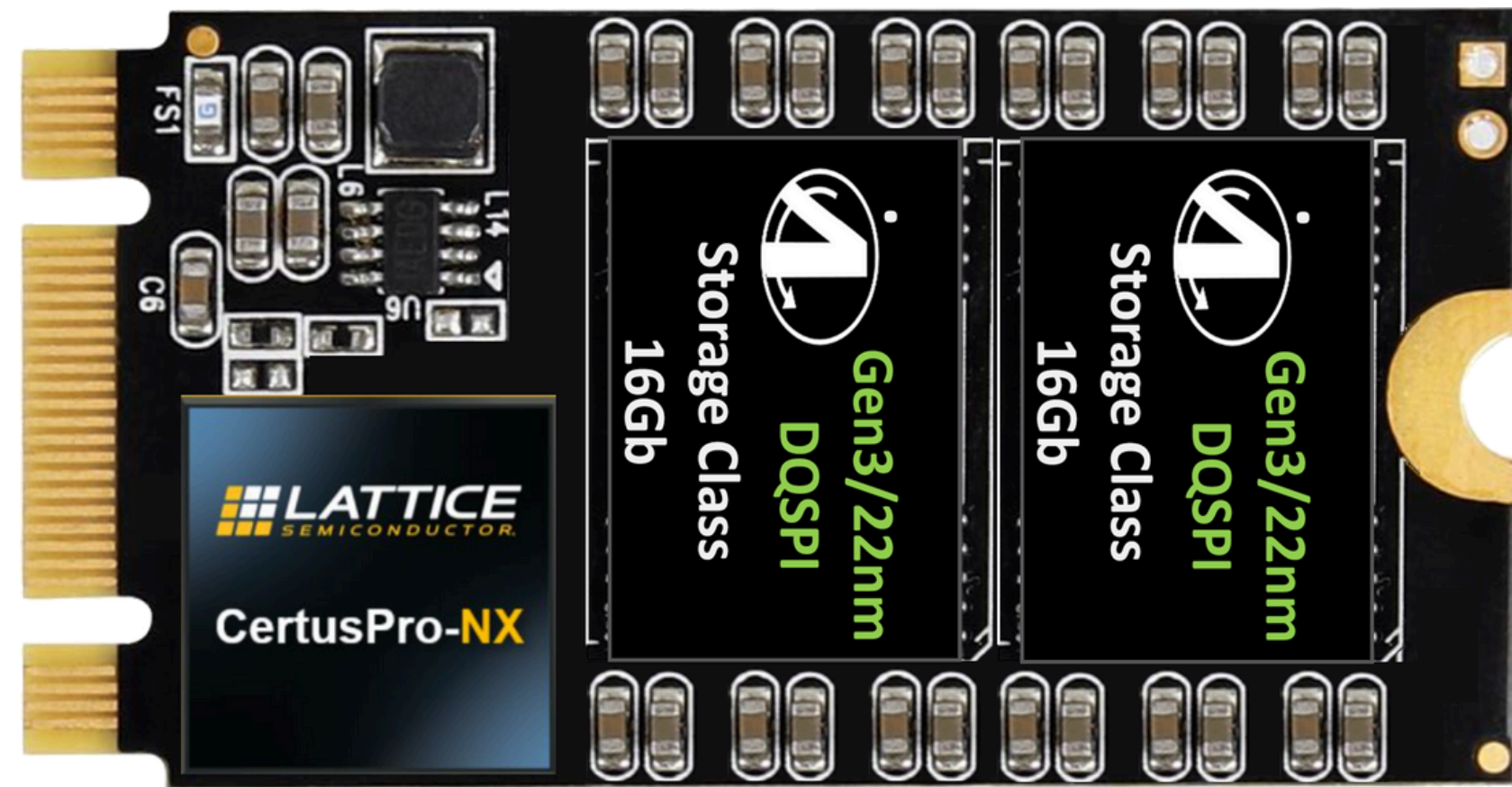

64Mb
Die

Enabled Platforms - Storage

Avionics and Space Grade Storage Class Products



16Gb MRAM Single Chip

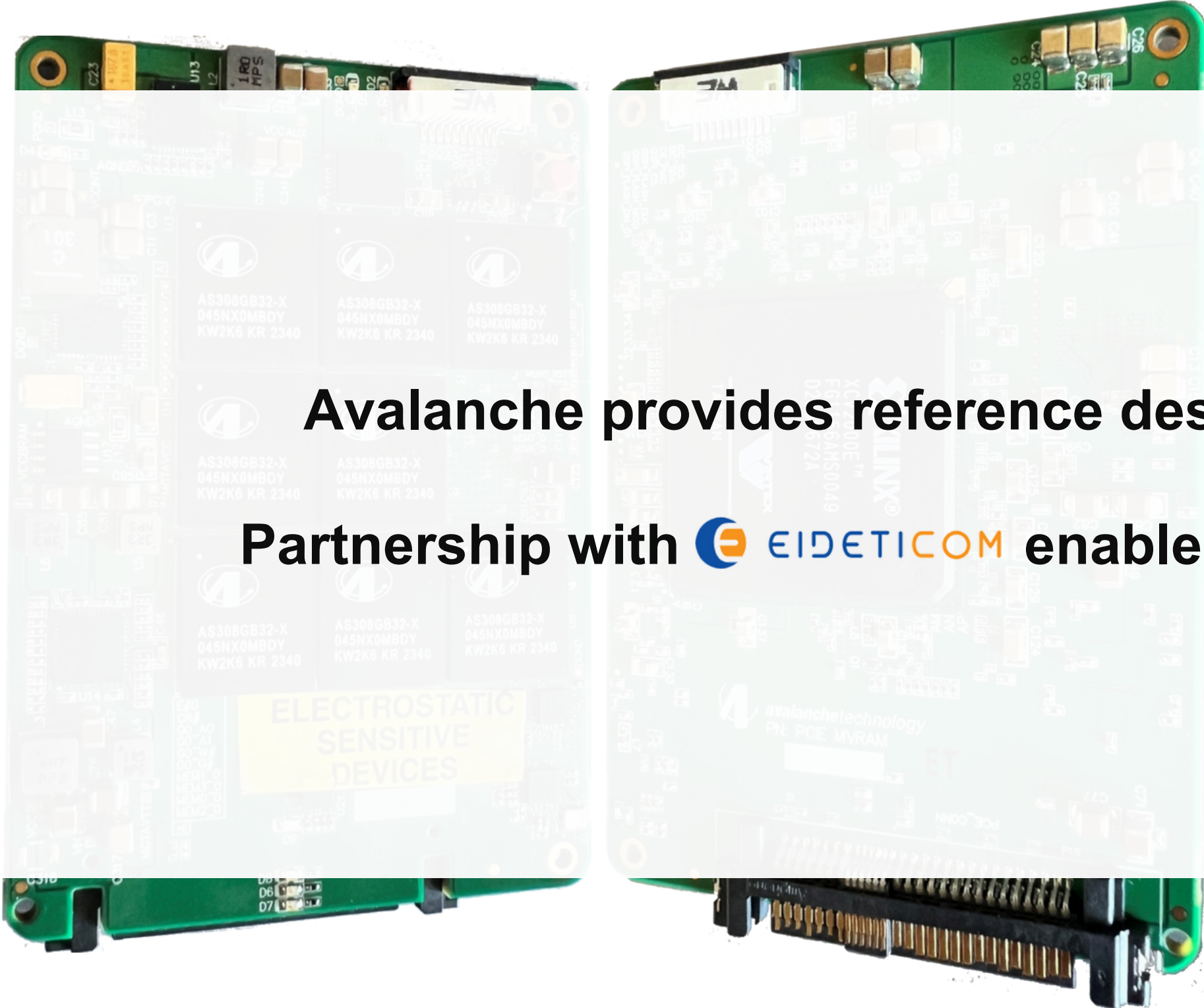


M.2 64Gb (8Gbyte) MRAM Module

EM configuration uses standard M.2 connector

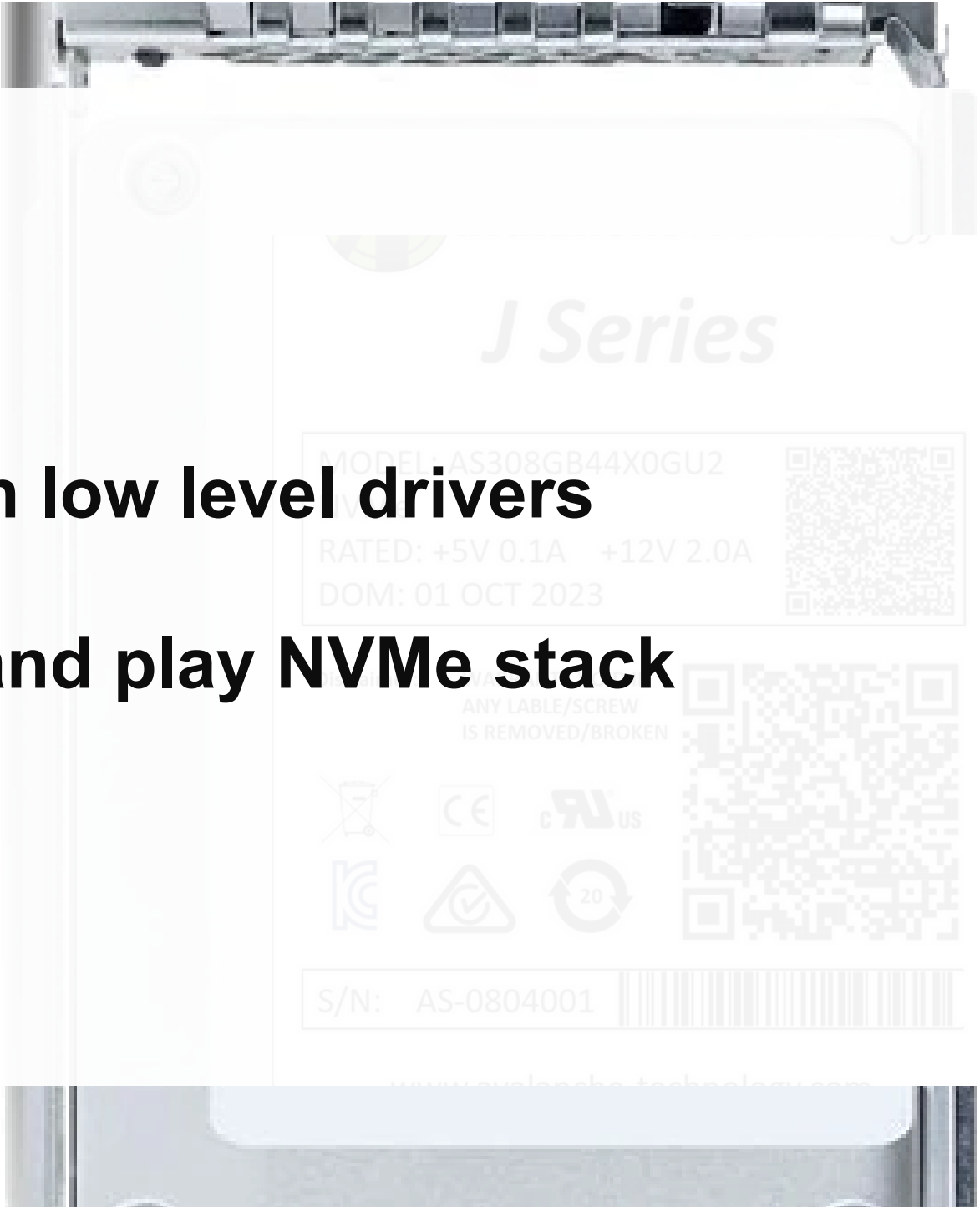
Ruggedized modules use BGA mounting style

Enabling the driver for Storage Solutions in Space



Avalanche provides reference design with low level drivers

Partnership with  enabled plug and play NVMe stack





enabled 8Gbyte MRAM Data Buffer

8GByte All MRAM Data Buffer

Licensed NVMe stack from  EIDETICOM

AI Memory: Xilinx KU060 FPGA supports data operations:

Compression, Cyber Security, Parameter Extraction, etc.

High performance SSD

10^{16} Write Cycle Endurance

Low power

3U VPX

Affordable

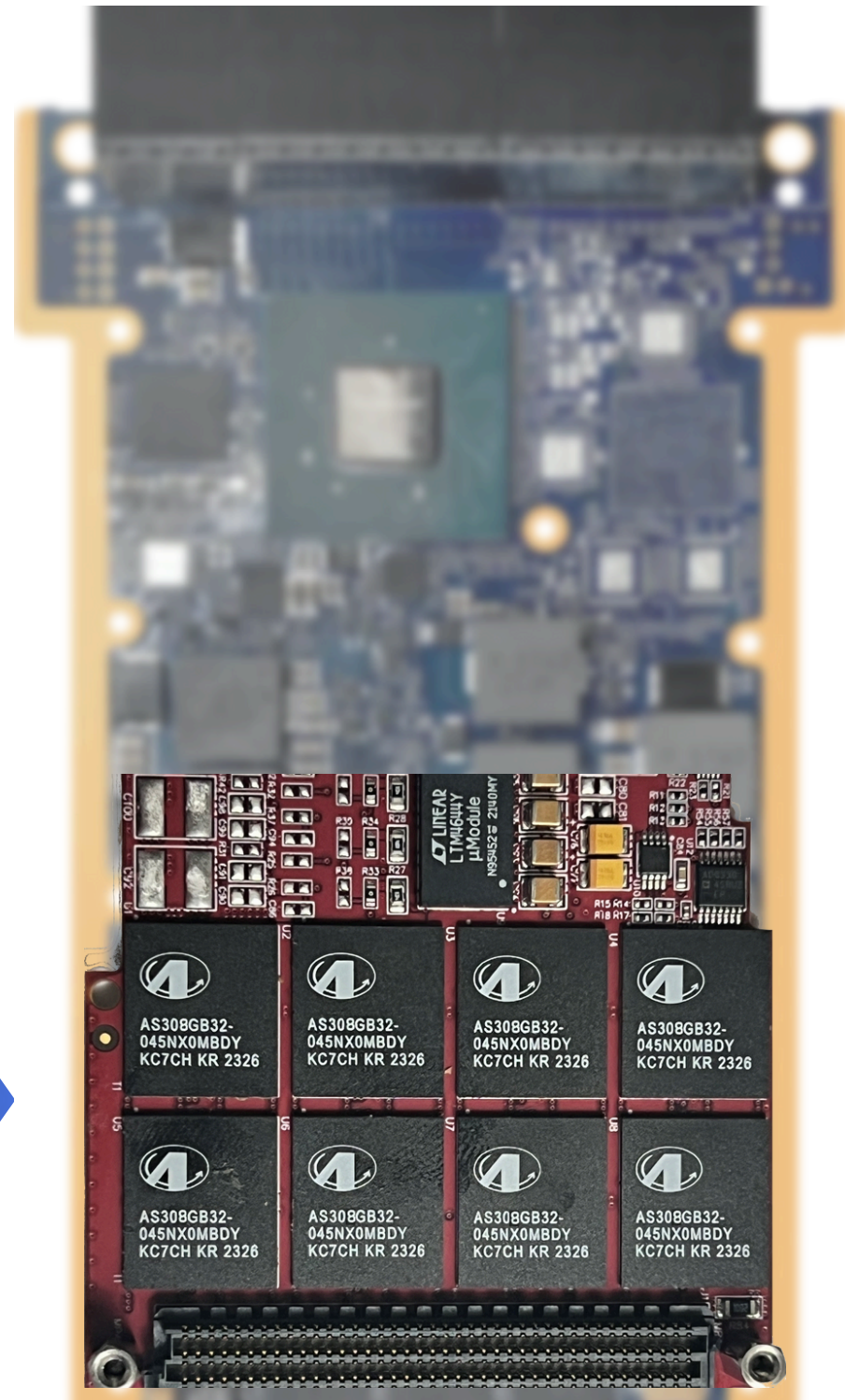




TRUSTED
Semiconductor Solutions™

enabled 8Gbyte Customizable Mezzanine Card

3U SpaceVPX
Processor Board



MRAM Data Buffer on
mezzanine card

MRAM 8GByte Cache daughter card

- Utilizes existing Xilinx Zynq board

Hi-Rel 3U VPX board based on Agilex-5

- Plan to make FMC compatible with MRAM Cache card

Radiation Circumvented 3U VPX board

- TSS developing PDDIC that detects, circumvents, and recovers from a radiation event
- Will use the Agilex-5

mercury enabled Hybrid (MRAM+NAND) SpaceDrives

In Development

Quadrium 3U VPX Rad-Tolerant, Mini-SpaceDrive

Multi-Host, 350 GBytes NAND, **120 MBytes MRAM**, 3.2 Gbit/s, Parallel, Octal SPI, SpaceFibre

Models: RH3350NM6S-000I01-01

- Rad-Tolerant non-volatile storage: 350 GBytes NAND plus 120 MBytes MRAM
- Triple-Redundancy for host Data and internal ECC bytes. Four, 8-bit, ECC corrections every 16 bytes of data
- Lesser screened, plastic RTG4 FPGA to enable cost sensitive NewSpace applications
- Rad-Tolerant, by design. All components except NAND.
- SpaceVPX compatible, 3U VPX form-factor, single 5V supply
- Lower cost, lower speed, implementation of Mercury's popular SpaceDrive product
- Multi-Host operation. Up to 6 hosts using Parallel, Octal SPI and SpaceFibre interfaces

The RMS350 is the first in a series of lower cost, radiation tolerant, NAND storage devices based on Mercury's popular SpaceDrive product. Using the latest generation of TLC NAND in SLC mode, the RH3350 is ideal for implementing high-reliability non-volatile storage in lower-cost applications requiring radiation tolerance.

Space grade reliability is accomplished using Rad-Tolerant, by-design components (except NAND), 3 copies of host and Reed Solomon data. To better enable lower cost NewSpace applications, lesser screened versions of true RT-by-design components are utilized. A full screened **Premium** version is available by special order.

The RMS350 replaces the cumbersome NAND flash command set and interface with flexible Parallel, SPI and SpaceFibre interfaces. Interfaces can be used together allowing multi-host operation. The full storage capacity is accessible by up to 6 hosts. Commands issued by interfaces are serviced based on bus ownership. Numerous status registers allow monitoring product health including PE counts, Retired Blocks, Spare Blocks, ECC errors and more. The RMS350 implements a deterministic corruption-free



In Development

Quadrium Rad-Tolerant, Triple Redundant, Mini-SpaceDrive
Multi-host, 350 GBytes NAND, **120 MBytes MRAM**, 3.2 Gbit/s, 120 pin Quad Plastic Package

Models: RMS350NM6S-000I01-01

- Rad-Tolerant non-volatile storage: 350 GBytes NAND plus 120 MBytes of MRAM
- Triple-Redundancy for Data and ECC bytes. Four, 8-bit, ECC corrections every 16 bytes of data
- Lesser screened RTG4 FPGA to better enable cost sensitive NewSpace applications
- Rad-Tolerant, by design. All components except NAND.
- Compact solder down form-factor, single 5V supply
- Lower cost implementation of Mercury's popular SpaceDrive product
- Multi-Host operation. Up to 6 hosts using Parallel, Octal SPI, SpaceFibre interfaces

The RMS350 is the first in a series of small form-factor radiation tolerant NAND storage devices based on Mercury's popular SpaceDrive (SSDR) product and packaged in a solder-down form-factor. Using the Micron B27C TLC NAND device in SLC mode, the RMS350 is ideal for implementing high-reliability non-volatile storage in lower-cost applications that require radiation tolerance.

Space grade reliability is accomplished using Rad-Tolerant, by-design components (except NAND), and 3 copies of host and Reed Solomon data. To better enable lower cost NewSpace applications, lesser screened versions of true RT-by-design components are utilized. A full screened Premium version is available by special order.

The RMS350 replaces the cumbersome NAND command set and interface with flexible Parallel, Octal SPI, and SpaceFibre interfaces. Interfaces can be used together allowing multi-host operation. The full storage capacity is accessible by up to 6 hosts. Commands issued by interfaces are serviced based on bus ownership and order received. Numerous status registers allow monitoring product health including PE counts, Retired Blocks, Spare Blocks, ECC errors and more. The RMS350 implements a deterministic, corruption-free shutdown process with an optional external capacitor to supply a

- NAND/MRAM SEE mitigation
 - Optional power cycle protection
 - Physical X,Y placement
- Data reliability:
 - Triple redundant Host Data
 - Four 8-bit corrections per byte
 - Automatic retirement
 - PE cycle tracking for a
- Performance (up to 400 Mbytes/s)
 - One 32-bit parallel interface
 - Two 16-bit parallel interfaces
 - Four 8-bit parallel interfaces
 - Octal SPI interface
 - SpaceFiber interface:
- NAND endurance:
 - Minimum 60,000 drive cycles
 - Total Bytes Written (TBW) 100TB
 - Up to 32 full drive overwrites
 - 1-month retention at 100°C
 - Host capacity is constant



CONCEPT

Rad-Tolerant 6U VPX 100 Gbit/s Quad-Host SpaceDrive
Host Capacity of 22 TB NAND plus **400 MBytes MRAM**, PCIe and mFAST interface options

Models:

RH622TNM6S-000I22-01 (22 TB EDU), RH622TNM6S-000I22-02 (22 TB Flight unit)



- Radiation-tolerant storage for space and commercial applications with potential for radiation exposure
- 22 TB using 3D TLC NAND in SLC mode (60K PE cycles)
- 400 Mbytes of general purpose MRAM (100 MB/s)
- 6U VITA 78, 220mm (SpaceVPX compatible) form-factor
- Rad-Tolerant components
- Single 5V supply

The RH622T is the second product in the Mercury's **SpaceMax** series of radiation tolerant SpaceDrives. Designed to maximize both performance and capacity, the RH622T supports a raw data rate of 160 Gbps and a sustained host data throughput of 100 Gbits/s. This represents a 5.5X improvement in performance and a 4.8X increase in capacity compared to the Boron 4.5TB SpaceDrive.

Like all members of the **SpaceMax** series, the RH622T utilizes the latest generation of 3D TLC NAND running in SLC mode. Host capacity remains constant across the entire life through use of very strong error correction and more than 16% of additional capacity dedicated to spare blocks.

To keep power consumption low, the RH622T utilizes multiple low power PolarFire FPGAs operating in parallel. Each PolarFire manages 25% of the capacity using four 10-Gbps SERDES Lanes per PolarFire. A single host can control the entire capacity, or four hosts can each control 25% of the capacity independent from the other 75% of the capacity.

Designed for fault-tolerance with multiple failed NAND devices, the RH622T SpaceDrive is the world's fastest and most reliable nonvolatile VPX storage device and is ideal for applications where full-time availability and high reliability are requirements.

- Radiation-tolerant design details:
 - NAND: Micron B27C die, PEM. TID >30 krad. Screened to EEE-INST-002
 - MRAM: Avalanche Gen3. 100 krad TID, SEE > LET 45 MeV.cm²/mg
 - PolarFire NAND Controller
 - TMR of critical logic. 1.2V I/Os for best SEL tolerance.
 - Total ionizing dose (TID) > 100 krad
 - Configuration upsets immunity to LET > 80 MeV.cm²/mg
 - Single-event latch-up (SEL) immunity to LET > 80 MeV.cm²/mg
 - Registers SEU rate < 10-12 errors/bit-day (GEO Solar Min)
 - SET upset rate < 10-8 errors/bit-day (GEO Solar Min)
 - All other devices: Radiation Tolerant, by design, to >100K rad
- VPX connectors:
 - Guide block key is adjustable and ships in the 0° position
 - Smith's KVPX Series: 500 mate/unmated cycles
 - TE connectivity MultiGig RT 2-R Series: 500 mate/unmated cycles
- Operating modes: Linear and Host Addressable
 - Linear Mode: Sequential data recording (Data recorder mode)
 - Host Addressable mode: operations on individual NAND blocks
 - Random SuperPage read operations: Both modes.
 - SuperPage size: 294,912 (per Port), 1,179,648 (4-Port mode)
 - SuperBlock size: 339,738,624 (per Port), 1,358,954,496 (4-Port mode)
 - UltraBlock size: 5,435,817,984 (per Port), 21,743,271,936 (4-Port mode). 1024 UltraBlocks

Enabled Platforms - Board & Device

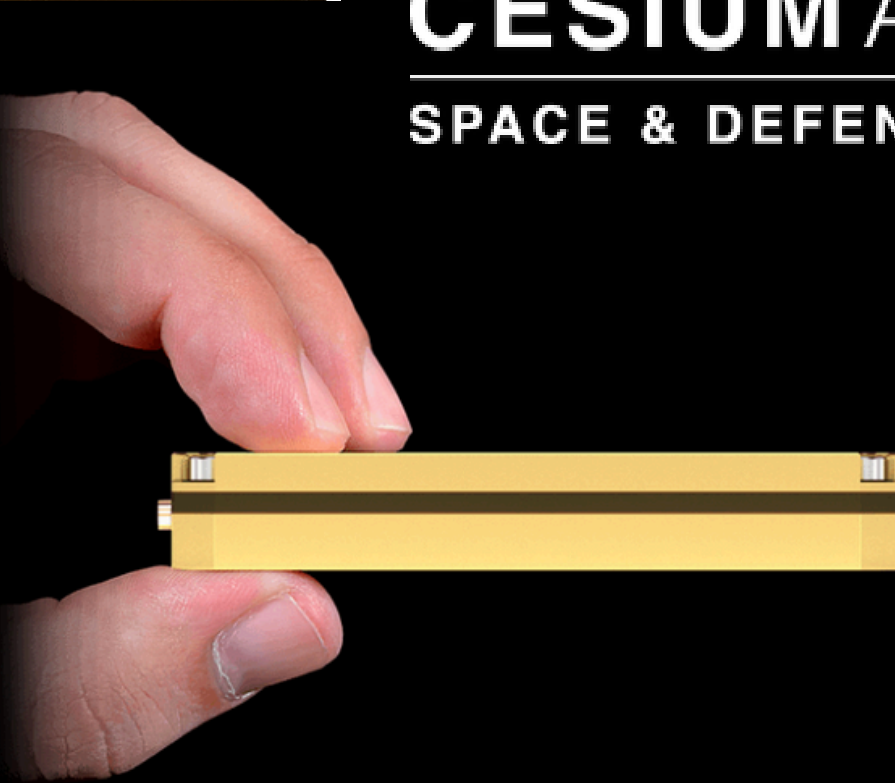
Advanced Boot Solutions Enabling SW-Defined Platforms

Avalanche Technology Announces Support for NASA PEMS Qualification and Screening

Avalanche Technology Selected to Support Mercury's First Space-Qu Processing Board Using AMD's Xilinx Versal AI Core



CESIUM ASTRO
SPACE & DEFENSE SYSTEMS



In response to unprecedented demand for extended qualification & screening compatible NASA PEMS options for enabling Dual QSPI MRAM family.

FREMONT, CA, April 8, 2024 — Avalanche Technology, the leader in next-generation persistent-SRAM (P-SRAM) products were announced today the launch of a new product derivative to address the aerospace and defense community for extended qualification and screening solutions, particularly NASA PEMS INST-0001.

Leveraging Avalanche's Gen 3 Space Grade MRAM products being broadly adopted by the defense industrial base and commercial space customers, the new pin compatible PEMS qualified and screened versions of the popular Dual QSPI MRAMs will roll out mid-year.

to build the next family of SWaP optimized

Avalanche Technology, the leader in next-generation persistent-SRAM (P-SRAM) products were selected by Mercury Systems for the new SCFE6933, a next-generation processor board that will enable the fast processing of data in orbit. The high-density 8Gb DQSPI Space Grade Persistent SRAM with further scalability is the ideal companion to the AMD (Xilinx) Versal Adaptive SoC platform that is feature-rich.

Support Resources @ www.avalanche-technology.com

Datasheets, models, reference designs

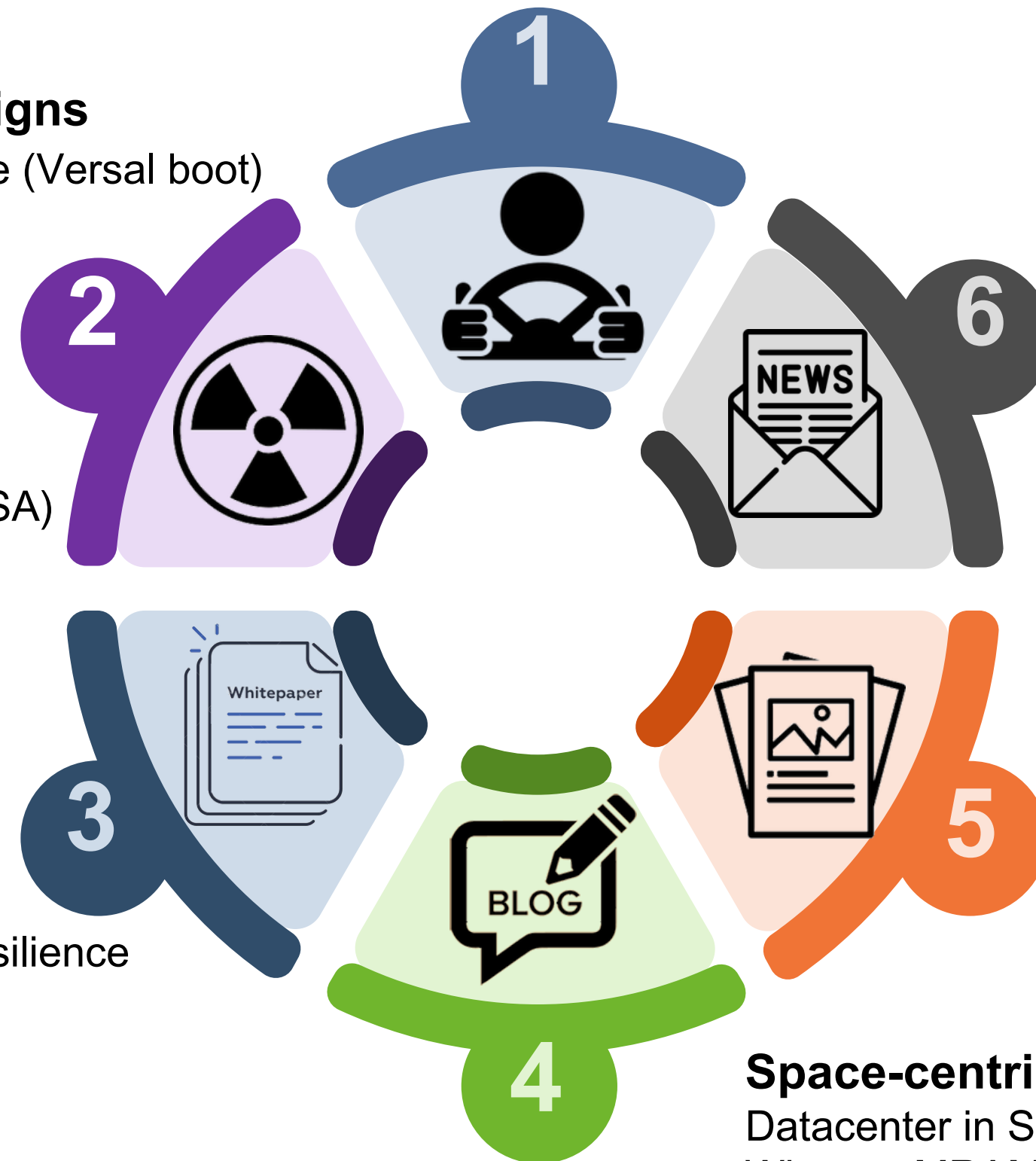
Boot module: Petalinux drivers, User Guide (Versal boot)
Gen 3 reference designs
IBIS & Verilog models

Radiation test reports

Gen 2 test report accessed via website (NASA)
Gen 3 reports available by request

Visionary White Papers

Innovation enabled by Avalanche
Data Centers in Space...
...why the key to satellite scalability and resilience
NEW: AI Computing in Space



Newsletters

Quarterly, *register on main page*

Brochures

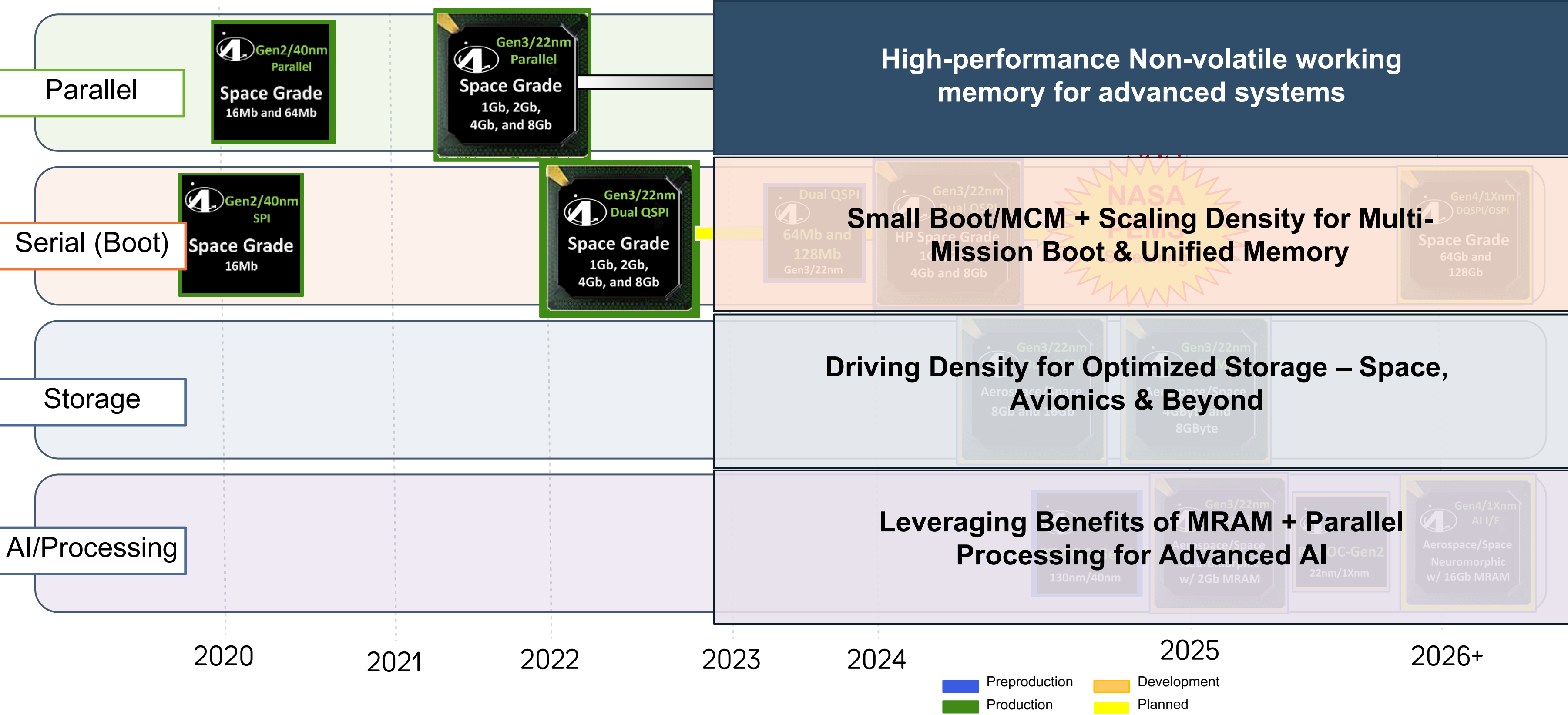
Overall MRAM tech for hi-rel apps
Space Grade products

Space-centric Blogs

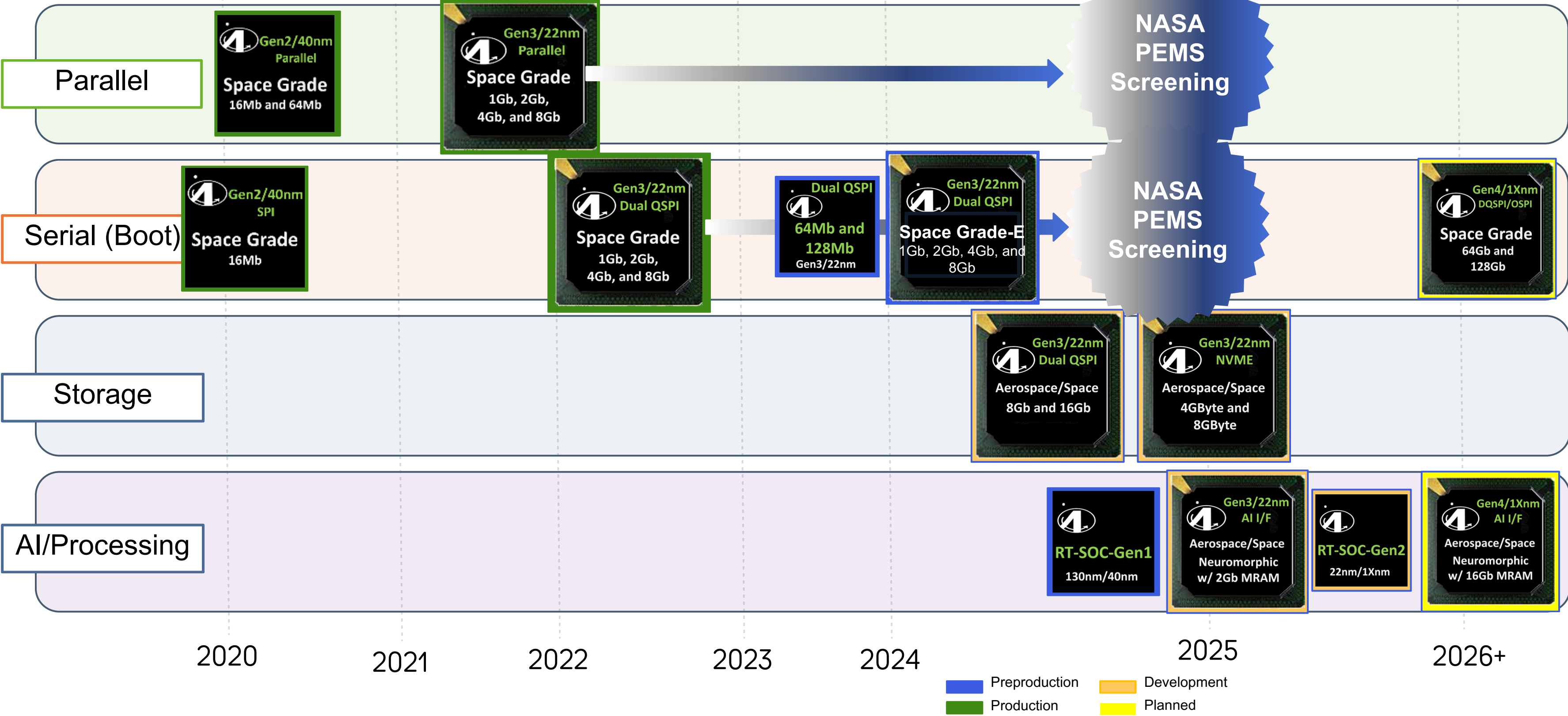
Datacenter in Space series
Why our MRAM is ideal for space

Recap

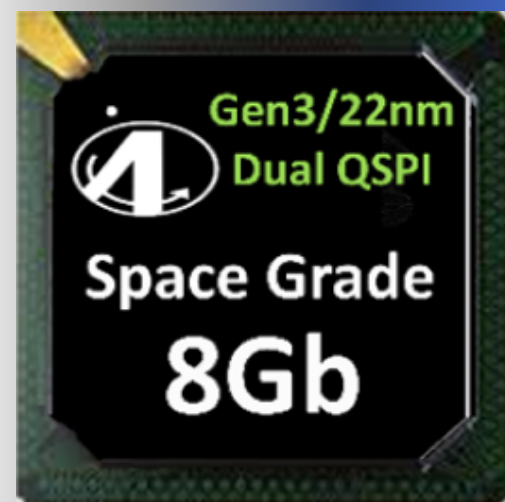
Avalanche MRAM/Processing Product Roadmap



Avalanche MRAM/Processing Product Roadmap



Thank You



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